PATENT SPECIFICATION

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688,727

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COMPLETE SPECIFICATION

Positive Shut-Off Ported Casing Apparatus for Well Cementing

We, BAKER OIL TOOLS, INC., a corporation duly organized under the laws of the State of California, of 6000, South Boyle Avenue, Los Angeles, State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to devices adapted to form part of casing, liners and similar conduits in well bores, and more particularly to side ported cementing devices for use in cementing in well bores.

Well casing, liners and similar well conduits are sometimes secured in well bores by discharging cementitious material through side ports in a fitting or fittings forming part of the conduit structure itself. After the cementing operation has been performed, it is desired to render the fitting imperforate by closing its ports against passage of fluids in both directions between the interior and exterior of the fitting.

An object of the present invention is to provide an improved ported apparatus in which the ports are initially closed, the ports being capable of being opened and then reclosed to prevent fluid flow through them in both directions between the interior and exterior of the apparatus.

Another object of the invention is to prevent inadvertent opening of the apparatus ports after they have been reclosed.

Still another object of the invention is to provide improved means for locking a sleeve valve or the like in a predetermined position with respect to the ports of a conduit apparatus.

A further object of the invention is to provide improved stop means for limiting the extent of downward movement of a sleeve valve adapted to control fluid flow through the ports of a conduit apparatus.

A further object of the invention is to provide improved means for minimizing or eliminating the resistance that would otherwise be offered by a dead column of fluid to downward shifting of the sleeve valve member.

Another object of the invention is to effect a substantial increase in the hydraulic force applicable to the sleeve valve, in shifting it to a desired position, without increasing the unit pressure of the fluid. In fact, a greater total force is available with a lesser unit pressure than heretofore necessary.

According to the present invention there is provided a valve controlled ported casing apparatus for well cementing in which a conduit is positionable in a well bore including a tubular member having a side port and adapted to form a part of said conduit string with an outer sleeve valve member on the exterior of the tubular member disposed initially in a position to allow fluid passage through said port and a lower inner sleeve valve member disposed initially across said port to close the same, the outer sleeve valve member being hydraulically shiftable to port closing position by fluid fed under pressure through an opening in the tubular member which is normally closed by a releasably secured upper inner sleeve valve member within the tubular member until the latter valve is shifted, whereby fluid flow is controllable through said port.

This invention possesses many other advantages which may be made more clearly apparent from a consideration of a form in which it is embodied. This form is shown in the drawings accompanying and forming part of the present specification, and will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be

taken in a limiting sense, since the scope of the invention is defined by the appended claims.

Referring to the drawings:—

Figure 1 is a longitudinal section through a ported well apparatus, with the ports closed and the parts arranged for running the apparatus in a well bore;

Fig. 2 is a view similar to Fig. 1, with the ports open;

Fig. 3 is a view similar to Fig. 1, with the parts occupying another position;

Fig. 4 is a view similar to Fig. 1, with the outer sleeve valve moved partially downward to a position closing the ports;

Fig. 5 is a view similar to Fig. 1, disclosing one manner of closing the ports;

Fig. 6 is a view similar to Fig. 1, disclosing another manner of closing the ports;

Fig. 7 is an enlarged longitudinal section through the tripping device for the lower inner sleeve valve member; and

Fig. 8 is a cross-section taken along the line 8—8 on Fig. 1.

As disclosed in the drawings, a casing collar A has its upper and lower ends threadedly connected to the ends of upper and lower casing sections B, C forming part of a casing string adapted to be run in a well bore to position the collar at the desired location therein.

The collar A includes a tubular member 10 whose lower end consists of a coupling 11 threaded on to the upper end of the lower casing section C. A stop member 12 is secured to the exterior of the coupling, as by the use of welding material 13, to serve a purpose described below.

The tubular member 10 has a plurality of circularly spaced side ports 14 through which fluids are adapted to pass between the interior and exterior of the collar apparatus. These ports are closed initially by a lower inner sleeve valve member 15 having seal rings 16, 17 disposed in suitable ring grooves 18 on opposite sides of the ports. These rings may be of rubber and of round cross section to prevent leakage thereby in both longitudinal directions.

The lower inner sleeve valve member 15 is retained in position to locate its seal rings 16, 17 on opposite sides of the ports 14 by one or more frangible devices in the form of shear screws 19 threaded through the tubular member 10 and extending into the valve member. This member 15 also carries a side seal 20 in a groove 21 below the shear screws 19. The seal 20 has an upwardly extending lip 22 for sealing with the wall of the tubular member 10.

It is to be noted that the inside diameter of the tubular member 10, at the region where it is engaged by the lower seal ring 17, is less than the internal diameter of a groove 23 in the member 10 immediately below this region. Also, the sleeve valve member 15 is reduced in external diameter to form a peripheral groove 24 below the lower seal ring 17, in which a split, inherently-expansible stop ring 25 is located. The stop ring has an upper inner inclined surface 26 tapering downwardly and inwardly for co-operation with a corresponding tapered surface 27 on the base of the peripheral groove 24. The length of the groove 24 is much greater than the length of the stop ring to permit downward movement of the sleeve valve member 15 relative to the stop ring.

The ring 25 is received within the enlarged diameter portion 23 of the tubular member. This enlarged portion is much longer than the height of the stop ring. The stop ring may rest upon a shoulder 28 provided by the lower end of the peripheral groove 24, the upper end of the stop ring being engageable with an upper shoulder 29 of the peripheral groove 24. Downward movement of the stop ring is limited by its engagement with a shoulder 30 formed by the lower end of the tubular member groove 23.

The shear screws 19 are adapted to be disrupted and the lower inner sleeve valve member 15 moved downwardly to a position in which the upper seal ring 16 is disposed below the ports 14. The ports are then open to the passage of fluid between the interior and exterior of the apparatus.

After the ports have been opened, it is desired to reclose them. To accomplish this purpose, an external sleeve valve member 31 is provided on the tubular member 10. This external member has a plurality of longitudinally spaced seal rings 32, 33 disposed in internal grooves 34 and is slidably engageable with the outer surface of the tubular member 10. The outer member 31 has an upwardly extending cylinder 35 integral therewith, or otherwise suitably secured thereto, which is slidable along an enlarged portion 10*a* of the tubular member.

The outer member 31 is retained initially in an upward position, in which it does not close the ports 14, by one or more shear screws 36 threaded through the cylinder 35 into the enlarged portion 10*a* of the tubular member. These screws are disruptable hydraulically by fluid pressure, including fluid under pressure entering through one or more elongate ports, slots or openings 37 in the tubular member into a cylinder space 38. This space is formed between the enlarged portion 10*a* of the tubular member, the

cylinder skirt 35 and the parts $31a$ of the sleeve valve member carrying the seal rings 32, 33. Leakage in a downward direction between the sleeve valve member 31 and tubular member 10 is prevented by the seal ring 32. Leakage in an upward direction therebetween is prevented by a seal ring 39 disposed in a peripheral groove 40 in the enlarged portion $10a$ of the tubular member, which sealingly engages the inner surface of the cylinder 35.

When sufficient hydraulic force is exerted on the outer sleeve valve member 31, the shear screws 36 will be disrupted and the outer sleeve valve member 31 shifted downwardly to a position in which its seal rings 32, 33 are located on opposite sides of the ports 14, closing such ports against passage of fluids therethrough in both directions between the interior and exterior of the apparatus. This position of the sleeve valve member 31 is determined by engagement of its depending skirt 41 with the upper end of the stop member 12. It is to be noted that the upper portion of the skirt 41 is spaced outwardly from the tubular member 10 so as to avoid interfering with passage of fluids through the ports 14 afer they have been opened. This fluid flows through the ports 14 and through slots $41a$ in the lower end of the skirt. The end is slidable upon the member 10 and has a lower, knife-like edge $41b$ capable of cutting through any materials that might coat the member 10, or tend to prevent downward movement of the outer sleeve valve member 31.

After the outer sleeve valve member 31 has been shifted downwardly to port-closing position, it is prevented from moving upwardly again by a latch or lock ring 42 disposed within a peripheral groove 43 in the tubular member 10 above its seal ring 39. This lock ring consists of a split, inherently expansible member having a reduced diameter lower portion $42a$ forming a shoulder 44 with the upper portion $42b$. The shoulder is inclined outwardly in a downward direction to a slight extent.

When the outer sleeve valve member 31 has been forced downwardly to essentially its fullest extent, the upper end $35a$ of the cylinder is disposed below the shoulder 44 of the split lock ring, but not below the lower end of its reduced diameter portion $42a$. As a matter of fact, the upper part of the cylinder 35 will be in engagement with the outer surface of the reduced diameter portion $42a$, the lock ring 42 inherently expanding outwardly to a certain extent upon riding of the cylinder off its upper portion $42b$. Any tendency for the outer sleeve valve member 31 to move upwardly will be limited by engagement of the upper cylinder end $35a$ with the lock ring shoulder 44, the lock ring being forced against the upper end of the peripheral groove 43. To insure against inward forcing of the lock ring 42 from engagement with the end $35a$ of the cylinder, the latter is tapered in the same direction as the shoulder 44, so that the two will remain in snug contact with one another.

The force of fluid under pressure is prevented from acting upon the external sleeve valve member 31 by an upper inner sleeve valve member 45 having longitudinally spaced seal rings 46 disposed in ring grooves 47 on opposite sides of the elongate ports or slots 37. This valve member is held in position by one or more shear screws 48 threaded through the tubular member 10 into the upper valve member 45. Disruption of the shear screws 48 and downward shifting of the upper sleeve valve member 45 will expose the ports 37 and permit fluid under pressure to pass through the latter into the cylinder space 38, in order to assist in shearing the cylinder screws 36 and moving the outer sleeve valve member 31 downwardly to port closing position.

The upper inner sleeve valve member 45 is not only used for the purpose of controlling the passage of fluid through the elongate ports 37, but is also used in assisting downward movement of the external sleeve valve member 31 to port closing position.

To accomplish this latter purpose, the upper inner sleeve valve member 45 and external sleeve valve 31 have an intervening lost motion connection. As specifically disclosed in the drawings, the outer sleeve valve 31 is formed with a plurality of inner keyways 80, in which are received the lug or arm portions 81 of keys 82 secured to the upper inner sleeve member 45 and extending outwardly through the elongate ports or slots 37. Each key includes a leg portion 83 depending from the arm portion 81 and adapted for movement within the tubular member 10 with the upper inner valve member 45.

It is to be noted that the arm 81 of each key is disposed originally above the lower end or shoulder 84 of the keyway 80. This arrangement is provided for the purpose of permitting the inner valve member 45 to move downwardly to an extent sufficient to shift the upper seal ring 46 below the upper ends of the ports 37, and thereby allow fluid to pass into the annular cylinder space 38 for action upon the sleeve 31 to effect shifting, or at least assisting in shifting, the sleeve valve 31 downwardly to port closing position. As

described in detail below, once the elongate ports 37 are open, fluid under pressure may enter the cylinder space 38 through these ports, disrupt the shear screws 36 and shift the outer valve member 31 downwardly to port closing position. If this hydraulic force is insufficient, then pressure may be imposed upon the entire cross-sectional area of the upper inner sleeve valve 45, which will be transmitted to the external sleeve valve 31 through the keys 82 and abutting shoulders 84.

As stated above, the lower sleeve valve member 15 is held initially in closed position by its shear screws 19. Similarly, the upper sleeve valve member 45 is held in closed position over the elongate ports 37 by shear screws 48, preferably closely adjacent or in abutting relation with the castellated upper end 15*a* of the lower valve member 15. The upper valve 45 has a central bore 49 whose wall tapers downwardly and inwardly. Similarly, the lower valve member 15 has a downwardly and inwardly tapering central bore 50, which, in effect, forms a continuation of the upper member bore 49. The cylinder screws 36 hold the outer valve member 31 in its upper position. The parts are all arranged as illustrated in Fig. 1, occupying their relative positions for lowering the apparatus into a well bore.

With both sets of ports 14, 37 closed, a fluent material, such as cement slurry, may be pumped directly into the casing string and through the central bores or passages 49, 50 in both sleeve valve members 45, 15, for discharge from the well casing at some point below the collar, as, for example, from a casing shoe (not shown). This charge of cement slurry will pass upwardly through the annulus around the casing string and may extend approximately to the location of the collar A, or slightly thereabove.

When it is desired to eject a second or upper charge of cement slurry through the collar ports 14, a trip device or plug member 51 is dropped into the well casing and is allowed to gravitate through the fluid therein into engagement with the wall of the central bore 50 in the lower sleeve valve member 15. As disclosed in the drawings, this trip device may consist of a substantially spherical head 52 having a rubber, or equivalent, spherical seal member 53 clamped thereon by a suitable depending extension 54 threaded on a neck 55 projecting downwardly from the head 52. The interior of the extension may be filled with lead 56, or similar weighting material, to insure rapid gravitation or descent of the trip device 51 through the fluid in the well casing.

The seal 53 on the trip device has a lesser external diameter than the minimum diameter of the tapered bore 49 in the upper sleeve valve member 45, to insure its complete passage through the latter. The spherical seal, however, has a diameter greater than the minimum diameter of the bore 50 through the lower valve member 15. As a result, the trip member comes to rest within the lower valve member with its head 52 and seal 53 closing its central bore or passage 50. Pressure may now be applied to the fluid in the casing above the trip member 51 and sleeve 15 in an amount sufficient to shear the screws 19 and shift the lower sleeve valve member 15 downwardly to port opening position, as shown in Fig. 2.

It is to be noted that the lower seal ring 18 engages the inner wall of the tubular member 10 only a slight distance above the larger diameter groove 23. Accordingly, upon shearing of the lower screws 19 and downward shifting of the sleeve valve 15 to an extent in which the lower "O" ring 18 is disposed within the groove 23, the fluid in the collar below the sleeve can then be displaced upwardly through the small running clearance space around the sleeve 15, around the seal ring 18 and out through the ports 14. Such upward flowing can take place, since the lower ring 18 is then disposed within the enlarged diameter bore 23 of the tubular member without making sealing engagement therewith. No difficulty is encountered in moving the lower sleeve valve 15 the slight distance necessary to dispose the lower seal ring 18 into the enlarged bore 23; whereas, considerable difficulty might be encountered in moving the lower sleeve valve 15 the substantial distance necessary to bring it into engagement with the stop 25 and to move such stop downwardly into engagement with the shoulder 30 formed by the lower end of the tubular member groove 23.

The additional seal ring 20 does not interfere with the bleeding of the fluid past the lower ring 18, in the manner described above. Its lip 22 will flex inwardly to allow bleeding but downward pressure imposed along the exterior of the sleeve valve 15 will force the lip 22 of the seal ring 20 outwardly against the tubular member 10 and prevent downward flow of fluid along the lower sleeve valve. This last-mentioned feature is provided in order to be assured that the fluid below the collar is not subjected to the cement pressure required to discharge the cement slurry outwardly through the port 14. It is sometimes desired not to disturb the lower cementing operation that has been performed previously, especially when

cement slurry is being discharged through the ports 14 before the lower charge of cement slurry has taken its initial set. The lip seal ring 20 effectively prevents any fluid pressure from being imposed on the lower cement job.

Downward movement of the lower valve member is limited by engagement of the stop ring 25 with the shoulder 30 of the tubular member 10, and of the shoulder 29 on the lower sleeve member 15 with the stop ring. Washing fluid, followed by cement slurry or other cementitious material, may now be discharged outwardly through the open ports 14, passing through the annular space between the tubular member 10 and the depending skirt 41 of the outer valve member 31, and through the slots 41*a* in the lower end of this skirt, for upward movement through the annulus around the collar A and casing string.

Upon discharging the required quantity of cement slurry, the outer sleeve valve 31 is forced downwardly to port closing position. This act may be accomplished by placing a top cementing plug 58 at the upper end of the charge of cement slurry pumped outwardly through the ports 14. This plug will come to rest within the bore 49 of the upper sleeve valve member 45, allowing the fluid in the casing string above the collar A to be pressurized to an extent sufficient for shearing the screws 48, to shift the upper inner valve member 45 downwardly to a position in which the upper ends of the elongate ports 37 are open (see Fig. 3).

The top cementing plug 58 disclosed in the drawings is of a composite character. It includes a lower nose 59, which may be made of magnesium, aluminium or other suitable, readily drillable material, having a tapered periphery 60 adapted to conform to the taper of the passage 49 in the upper sleeve 45. This nose is so proportioned as to seat within the passage and cause the top cementing plug 58 to come to rest therewithin. From its tapered nose, the lower end of the plug is integral with a central shank 61 terminating in a flange 62, received within a companion bore and recess 63 of a flexible portion 65 of the cementing plug. These two parts are suitably vulcanized together.

The flexible plug 65 is formed essentially of rubber or similar material. It has an inwardly compressible body portion 70 defined by tapered forward and rearward surfaces 71, 72 merging into an annular peripheral sealing surface 73 slidably engageable with the wall of the well casing. The plug 65 also has a tail portion 74 terminating in a fluted guide 75. Its annular sealing portion includes an upwardly extending lip 76 adapted to be forced outwardly by fluid pressure against the wall of the casing.

The tapered nose 59 on the lower plug portion has a greater diameter than the minimum diameter through the upper sleeve valve 45. As a result, it comes to rest within the tapered bore 49 of the latter, closing it against passage of fluid and allowing pressure to be built up in the casing fluid above the cementing plug 58, sufficient in extent to shear the screws 48 and shift the upper member 45 downwardly to a position limited by engagement of the key lugs 81 with the shoulders 84 forming the lower end of the keyways 80 in the outer sleeve 31 (see Fig. 3). When in this position, the upper ends of the elongate ports 37 are exposed, allowing fluid to pass into the cylinder space 38 for the purpose of shearing the cylinder screws 36 and moving the outer sleeve 31 downwardly to port closing position, such as disclosed in Fig. 5.

A standard top cementing plug would not permit fluid to pass by it and enter the ports 37. The flexible plug 65 described above, however, will have its body 70 and annular sealing portion 73 deformed inwardly to a sufficient extent to compress the rubber material into the tapered passage 49 through the upper inner valve member 45, sealing off this passage completely, while removing the annular sealing portion 73 of the plug from engagement with the casing wall or inner wall of the tubular member 10. The plug, therefore, offers no restriction or barrier to passage of fluid through the ports 37, for action upon the outer sleeve valve member 31.

In connection with the shifting of the outer sleeve valve 31 downwardly to port closing position, several conditions might be encountered in the well bore, tending to resist this action. As disclosed in Fig. 3, the upper inner sleeve valve 45 has been shifted downwardly to a position in which the key lugs 81 engage the lower shoulders 84 in the outer sleeve valve member, which, as described above, opens the ports 37. The application of pressure to the casing fluid above the top cementing plug 58 not only acts upon the annular cross-sectional area of the cylinder 35 in the space 38, but also upon the entire cross-sectional area of the flexible plug 65 and inner sleeve member 45. This pressure disrupts the shear screws 36 and shifts the upper inner valve member 45 and the outer valve member 31 downwardly as a unit, until the lower seal ring 33 on the outer member is disposed below the ports 14, thereby closing them.

During movement of the outer valve

member 31 and inner valve member 45 to the position just referred to, the cement slurry in the collar between the upper and lower valve members 45, 15 can pass outwardly through the open ports 14. However, since the lower seal ring 33 is now disposed below the ports 14, this slurry is trapped between the upper and lower sleeves 45, 15 and prevents further downward movement of the upper inner sleeve 45. Thereafter, the fluid pressure can act effectively on the annular cylinder 35 alone, to force the outer valve member 31 downwardly to port closing position, such as disclosed in Fig. 5. The lost motion connection 80, 81 between the inner and outer sleeves 45, 31 permits such occurrence without further downward shifting of the inner member 45. Under some circumstances, however, insufficient pressure can be built up for shifting the outer valve member 31 completely to its port closing position.

Well conditions, such as a high hydrostatic head of cement slurry around the exterior of the casing string above the ports 14, or hardened cement from the lower cementing operation around the tubular member 10 below the outer sleeve valve 31, and the like, may offer resistance to downward movement of the outer sleeve valve upon application of hydraulic pressure in the annular cylinder 35 alone. To insure an adequate hydraulic force to shift the outer sleeve valve member 31 downwardly to full port closing position, it is desired to transmit the force of the fluid pressure acting across the entire area of the plug 58 and sleeve 45 to the outer sleeve valve. This can be done upon eliminating the entrapped slurry from the region between the upper and lower inner sleeve valve members 45, 15.

This slurry can be removed in several manners, after the ports 14 have been closed by the outer sleeve valve 31 (Fig. 4). As disclosed most clearly in Figs. 2 and 6, the lower plug or trip device 51 includes an upper central passage 90 communicating with side ports 91 below the spherical seal 53. This central passage is originally closed by a plug or valve head 92 held in position by frangible means, such as a shear pin 93 extending between the spherical head 52 and the plug 92. Leakage around the plug can be prevented by a suitable side seal 94 engaging the wall of the central passage 90.

When sufficient pressure is imposed on the slurry entrapped between the upper and lower sleeve valve members 45, 15, the frangible pin 93 is disrupted, and the plug 92 in the trip device moved downwardly into an enlarged bore 95 formed in the extension 54 (Fig. 6). The slurry between the sleeve valve members 45, 15 can then pass through the open passage 90, through the enlarged bore 95, and through the ports 91 into the casing below the collar A. The release of such slurry permits the upper inner sleeve valve member 45 and top cementing plug 58 to move downwardly under the action of the hydraulic pressure thereabove, the hydraulic force being transmitted from the upper valve member through the keys 82 to the outer valve member 31, the inner and outer valve members being moved downwardly to the fullest extent, in which the upper end of the cylinder 35 is disposed below the latch shoulder 44 (see Fig. 6).

The slurry in the casing string below the collar A may also be a trapped body of slurry, but it is of such length (several hundred or several thousand feet) that the small quantity of slurry trapped between the upper and lower sleeves 45, 15 can still be forced through the trip device passages 90, 95, 91 downwardly into it. The slurry below the collar A is ordinarily of such character as to be partially compressible, even if only to a relatively minute extent.

The entrapped slurry may also be released by forming the lower trip device 51 with a chamber 96 that can have the required volume, and which is normally at atmospheric pressure (Fig. 7). This chamber is closed by the plug 92 held in place by the shear pin 93, in the same manner as described in connection with the other trip device.

Upon application of sufficient pressure to the top cementing plug 58 and upper inner valve member 45, the shear pin 93 is disrupted and the plug 92 moves downwardly into the air chamber 96, followed by the entrapped fluid between the members 45, 15. As a matter of fact, the disrupting of the frangible pin 93 will cause the air chamber 96 to effectively suck the entrapped fluid downwardly into it.

Following release of the plug 92, the upper inner valve member 45 co-operates with the outer valve member 31 to shift the latter to port closing position, in the manner described above in connection with the other trip device.

It is, accordingly, apparent that a side ported cementing apparatus has been disclosed, in which the outer sleeve valve member 31 can be shifted to port closing position by fluid under pressure acting over a greater area than the annular cylindrical area associated with the outer valve member itself. The full cross sectional area of the top cementing plug 58 and inner sleeve valve 45 has the fluid pressure imposed upon it, and this entire total force is transmitted to the outer

valve member through the keys 82. Accordingly, considerable force is available to overcome the hydrostatic head of cement slurry, or any other forces, tending to resist full movement of the outer valve member 31 to port closing position. Of course, if a large resistance is not encountered, then the upper inner valve member 45 need not offer its assistance to shifting of the outer valve member 31 to port closing position, since the fluid under pressure acting on the annular cylindrical area alone would be sufficient to shift the outer sleeve valve downwardly to the extent required.

Should a greater force than can be exerted on the annular area be necessary, then the entrapped fluid is dissipated and the fluid under pressure, acting upon the entire cross sectional area of the top cementing plug 58 and upper sleeve 45 is available.

The top cementing plug 58 serves its normal function of confining the charge of cement slurry in advance of it by slidably sealing with the wall of the casing during its downward passage. The top cementing plug assists in releasing the upper valve member 45, to open the elongate ports 37, but still does not interfere with fluid passage into the annular cylinder space 38.

As indicated above, the lower plug or trip device 51 serves to release the entrapped fluid between the upper and lower sleeve valve members 45, 15.

What we claim is:—

1. Valve controlled ported casing apparatus for well cementing in which a conduit is positionable in a well bore including a tubular member having a side port and adapted to form a part of said conduit string with an outer sleeve valve member on the exterior of the tubular member disposed initially in a position to allow fluid passage through said port and a lower inner sleeve valve member disposed initially across said port to close the same, the outer sleeve valve member being hydraulically shiftable to port closing position by fluid fed under pressure through an opening in the tubular member which is normally closed by a releasably secured upper inner sleeve valve member within the tubular member until the latter valve is shifted, whereby fluid flow is controllable through said port.

2. Apparatus as set forth in Claim 1 in which means carried by the tubular member is provided for preventing the outer sleeve valve member from shifting from its port closing position.

3. Apparatus as set forth in Claim 2 in which the outer sleeve valve member has a cylinder portion slidable along the tubular member in leakproof relation therewith and in which fluid under pressure from the interior of said tubular member may be directed into the cylinder portion.

4. Apparatus as set forth in Claim 3 in which a ring is disposed in a recess in the tubular member engagable with an end of the outer sleeve valve member to limit the longitudinal movement of the latter along said tubular member.

5. Apparatus as set forth in Claim 1 in which the lower inner sleeve member has a seal ring which is sealingly engageable with the tubular member below said port for preventing fluid below the lower inner sleeve valve from passing upwardly between said members, said seal ring being so constructed and arranged as to become ineffective upon relatively slight downward shifting of the lower inner sleeve valve member to permit the passage of fluid, said tubular member having an internal diameter at its location of engagement with the seal ring which is less than its internal diameter a short distance below said location.

6. Apparatus as set forth in Claim 3 in which the upper inner sleeve valve member is keyed to the outer sleeve valve member through said opening and in which the upper inner sleeve valve member is hydraulically slidably operable.

7. Apparatus as set forth in Claim 6 including a top plug means adapted to be lowered through the conduit string into engagement with the upper inner sleeve valve member closing a passage therethrough thereby enabling the upper inner sleeve valve member to be shifted hydraulically downward to effect shifting of the outer sleeve valve member to port closing position.

8. Apparatus as set forth in Claim 7 in which said top plug means comprises a flexible material and has a portion in slidable sealing engagement with the conduit string, said sealing portion being adapted to be deformed and to enter the upper inner sleeve valve member for closing the passage therethrough.

9. Apparatus as set forth in Claim 7, including trip plug means having a releasably closed passage initially closing a passage through the lower inner sleeve valve member which hydraulically facilitates removal of fluid from the region between the inner sleeve valve members when the port is closed.

10. Valve controlled ported casing

apparatus substantially as described with reference to the accompanying drawings and for the purpose set forth.

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FIG. 1.

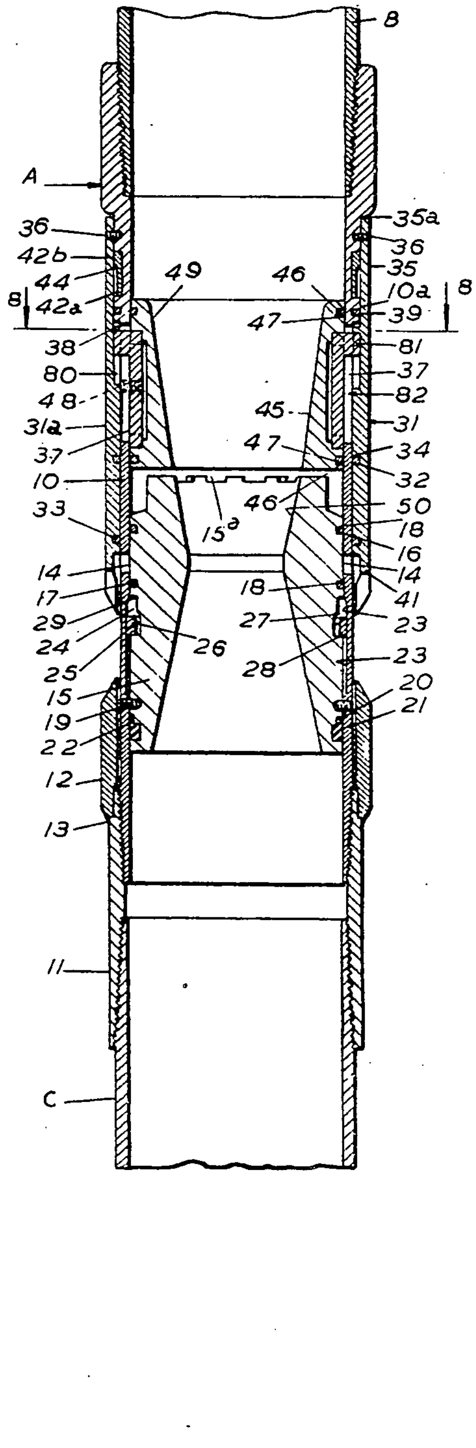
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FIG. 2.

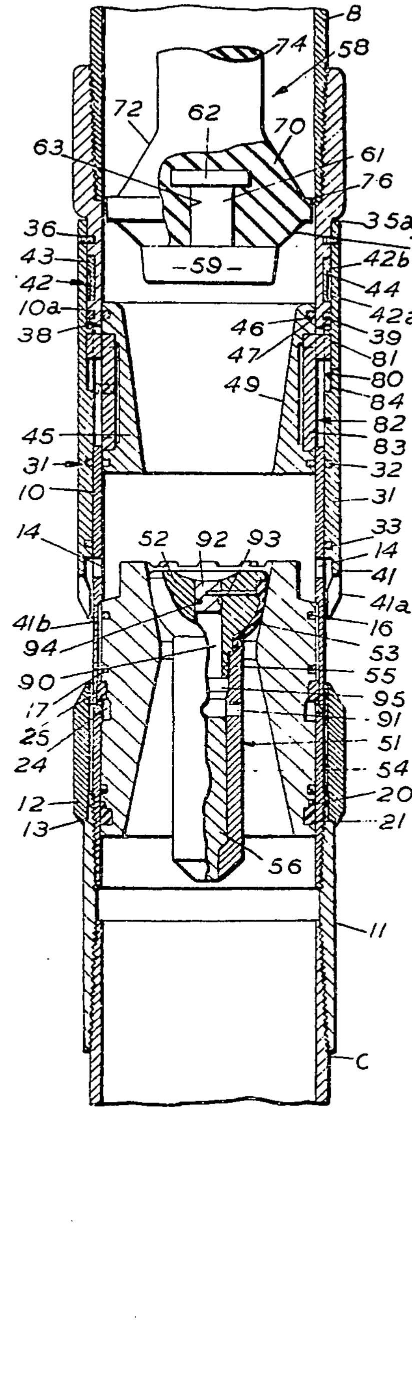
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FIG.3.

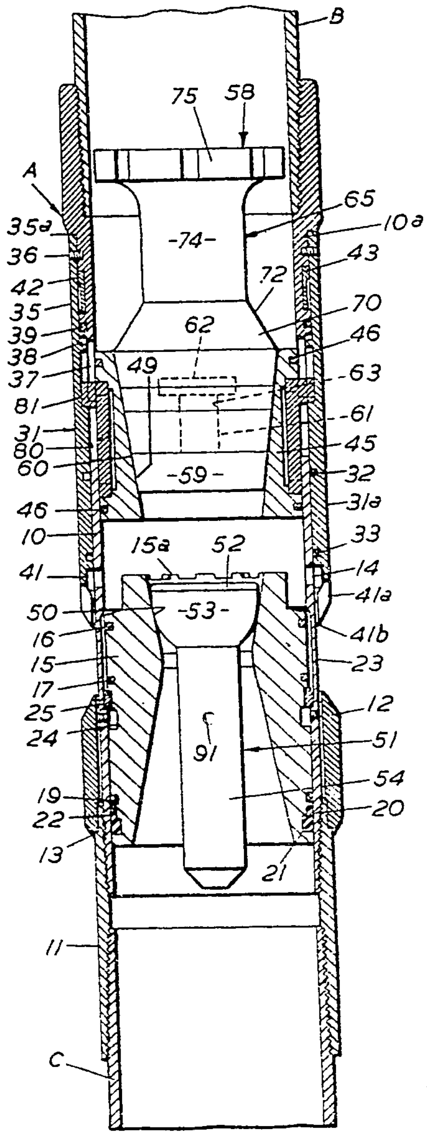
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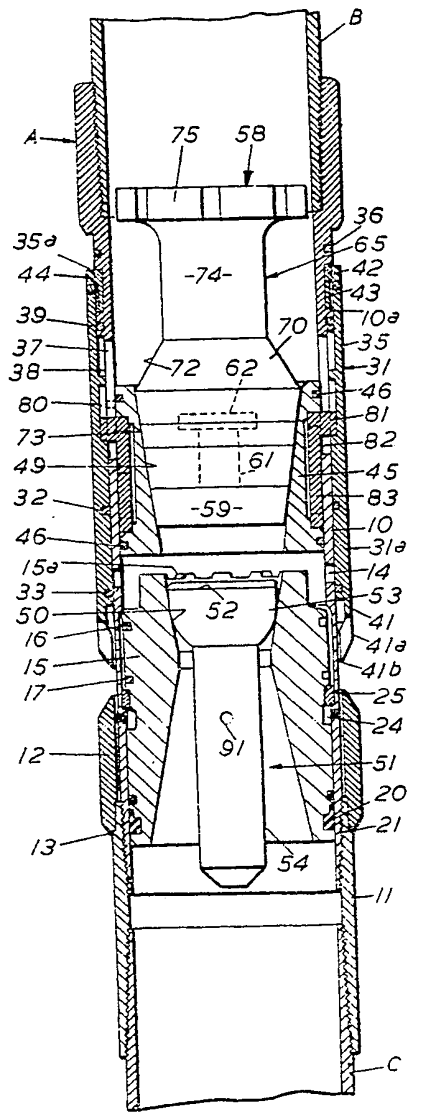
FIG.4.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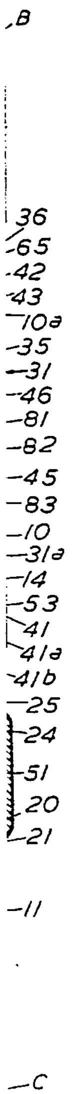
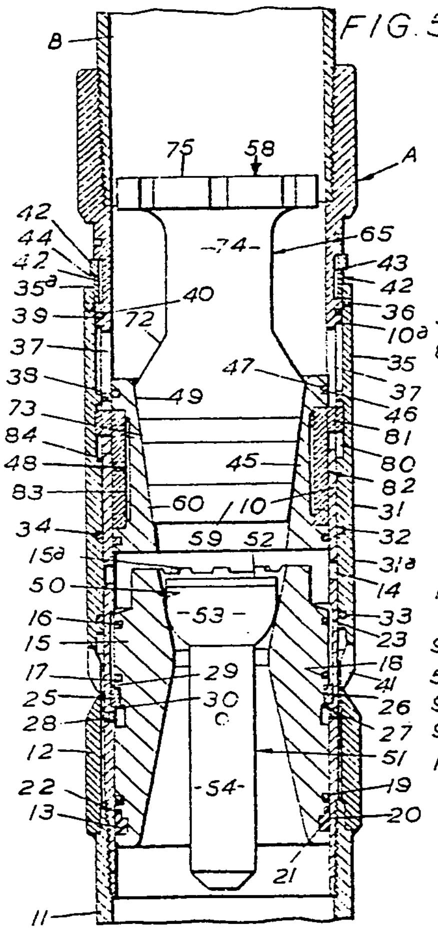




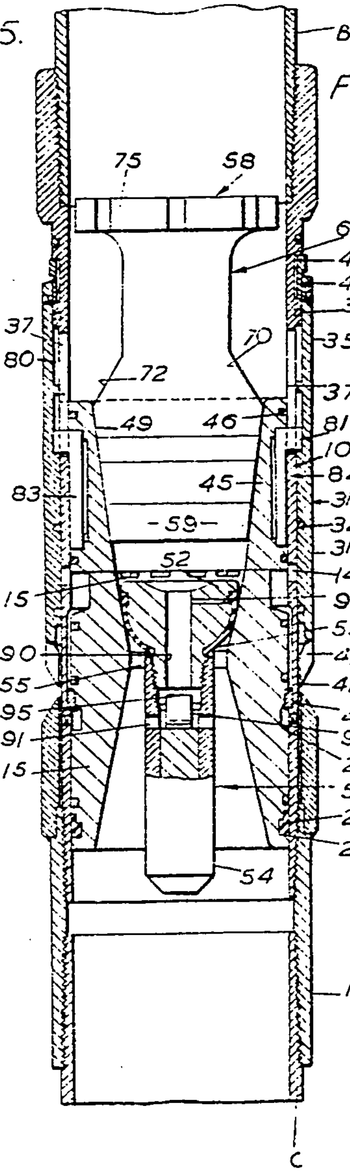


FIG. 5.

FIG. 6.

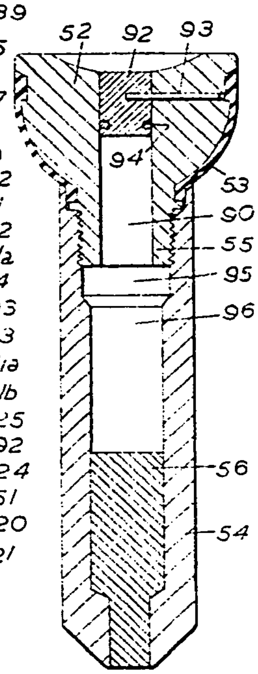


FIG. 7.

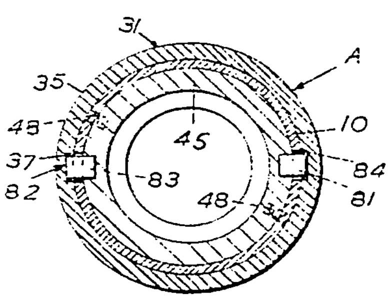


FIG. 8.

688,727 COMPLETE SPECIFICATION
3 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 2 & 3

FIG. 3

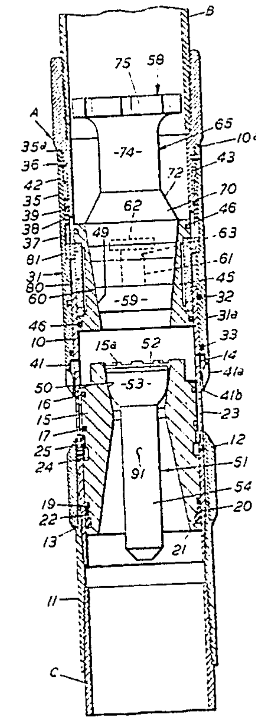


FIG. 4.

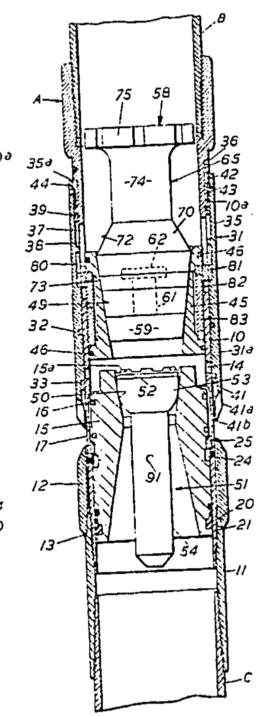


FIG 5.

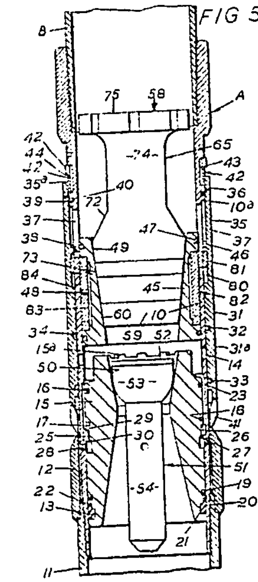
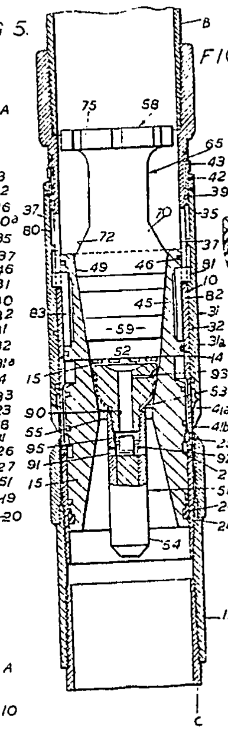


FIG. 6.



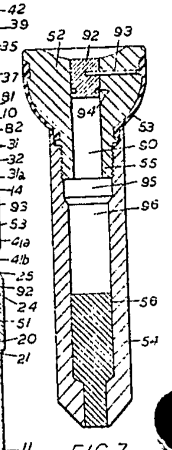


FIG. 7.

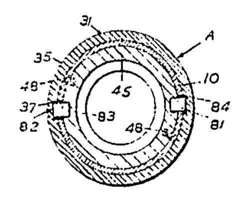


FIG. 8.